TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

EXAMINATIONS — 2008

MID-YEAR

COMP205 / ENGR202
Software Design and Engineering

Time Allowed: 3 Hours

Instructions: There are 180 possible marks on the exam.
Answer all questions in the boxes provided.
Every box requires an answer.
If additional space is required you may use a separate answer booklet.
Non-electronic Foreign language dictionaries are allowed.
Calculators ARE NOT ALLOWED.
No reference material is allowed.

Question	Topic	Marks
1.	Java Fundamentals I	30
2.	Principles of Software Design I	30
3.	Practices of Software Engineering I	30
4.	Java Fundamentals II	30
5.	Practices of Software Engineering II	30
6.	Principles of Software Design II	30
	Total	180

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Question 1. Java Fundamentals I [30 marks]

(a) Consider the following Java code which is part of an adventure game. It compiles and runs without error.

```
/** A Location represents a single room within the game. */
public class LOCATION {
    public ArrayList<Door> exits = new ArrayList<Door>();
    public ArrayList<I> items = new ArrayList<I>();
}

/** A Door connects two locations, and has a front and back side. */
public class Door {
    private LOCATION sideA, sideB;

    /** Construct Door */
    public Door(LOCATION sideA, LOCATION sideB) {
        this.sideA = sideA;
        this.sideB = sideB;
    }

    /** Get location on side A of door */
    public LOCATION getSideA() { return sideA; }
    /** Get location on side B of door */
    public LOCATION getSideB() { return sideB; }
}

/** Represents an item (e.g. furniture, coin, etc.) in the game. */
    public abstract class I {
private String name; // name
    private LOCATION location; // location containing this item

    /** Construct Item */
    public I(String zzz, LOCATION yyy) {
        this.name = zzz; // assign zzz to name field
        this.location = yyy; // assign zzz to name field
    }

    /** This method returns the items name. */
public String getName() { return name; }
    /** This method returns the items name. */
         public LOCATION getLocation(){return location;}
}

public class Coin extends I {
    public int value;
    public Coin(int value, String name, LOCATION location) {
        super(name,location);this.value=value;
}   }
```

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(i) [10 marks] Circle and number five separate problems of style with the four classes on the previous page. For each problem, write a brief (i.e. one or two line) description of the problem in the corresponding box below.

1)

2)

3)

4)

5)

(ii) [8 marks] In the box below, draw a *UML Class Diagram* for the classes shown on the previous page. (Show relationships, multiplicity and class attributes in your diagram, but not methods).

(b) Consider the following Java code, which compiles without error.

```
public boolean checkValid(LOCATION room) {
   // Look through exits of this room
   for(Door d : room.exits) {
        LOCATION next = d.getSideA();

        // which side doesn't this room lead to?
        if(next == room) { next = d.getSideB(); }
        // is the door there?
        if(!next.exits.contains(d)) { return false; }
        // now look through doors in next room
        if(!checkValid(next)) { return false; }
    }
    // Yes, it's all ok!
    return true;
}
```

(i) [7 marks] In the box below, briefly describe in your own words what this method does.

(ii) [5 marks] The method above contains a serious bug. Briefly describe what the problem is, and under what circumstances it occurs.

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Cross out rough working that you do not want marked.
Specify the question number for work that you do want marked.

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Question 2. Principles of Software Design I [30 marks]

(a) Consider the following specification for a music player.

> "A music player plays music when requested. A user can start, stop and pause playback, as well as fast-forward/rewind the current track. A *simple* music player is either a *cassette*, *CD* or *MP3* player. A *combination* music player consists of one or more simple music players (e.g. a cassette *and* CD player). "

(i) [2 marks] According to the specification, what *interface* does a music player have?

(ii) [2 marks] From the specification, what do you believe constitutes the *state* of a simple music player?

(iii) [2 marks] How would you justify the claim that a music player has *identity*?

(iv) [2 marks] According to the specification, what *inheritance* relationship exists amongst the different kinds of music player?

(v) [2 marks] What *Design Pattern* could be used to implement combination music players?

(b) Consider the following Java code, which compiles and runs without error.

```
public class SortedIntList {
  public ArrayList<Integer> ints = new ArrayList<Integer>();

  public void add(int x) { ints.add(x); Collections.sort(ints); }
  public void remove(int x) { ints.remove(x); }
}
```

(i) [2 marks] In the box below, give a Java method which accepts a `SortedIntList` and prints out its elements in order.

(ii) [4 marks] The `SortedIntList` class is not properly *encapsulated*. Identify two distinct ways a user can put a `SortedIntList` into an erroneous state.

(iii) [4 marks] Suppose you turned the `ints` field of `SortedIntList` into a `LinkedList`. Discuss what changes are necessary to code that uses a `SortedIntList`.

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(iv) [4 marks] Suppose you made the `ints` field of `SortedIntList` private. Briefly discuss what changes (if any) would be necessary to `SortedIntList`.

(v) [6 marks] Taking into consideration your answers to **(ii)**, **(iii)** and **(iv)**, discuss why *public fields* are considered harmful.

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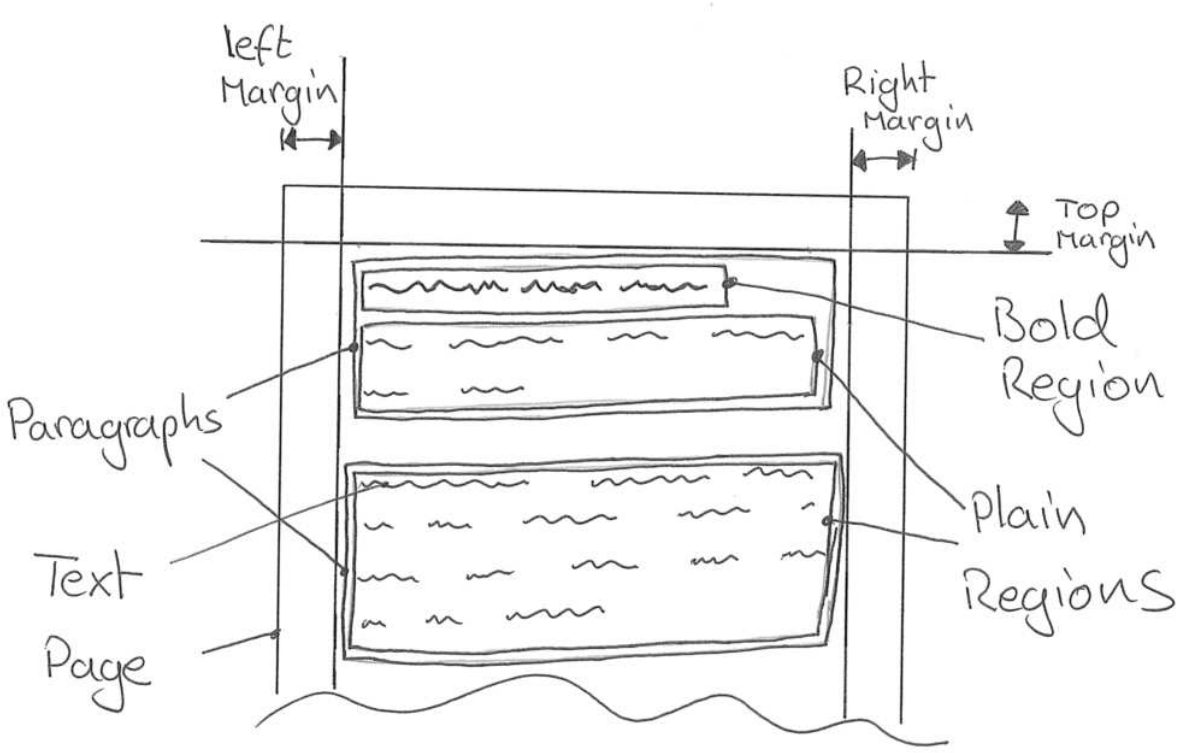
Question 3. Practices of Software Engineering I [30 marks]

You are part of a software team developing a word processing application. Your job is to develop the class structure for representing text documents. A rough description of a text document follows:

> "A text document contains one or more *pages* of text, where each page contains zero or more *paragraphs*. Each page has its own *left*, *right*, *top* and *bottom* margins; these measure the distance from the edges of the page.
>
> Paragraphs contain *formatted regions* of characters. Each formatted region is either: a *plain region*; a *bold region*; an *italic* region; or, a *font* region. Plain regions identify regions of text which have no formatting; bold and italic regions identify regions of text to be shown in **bold** or *italic*; finally, font regions identify regions of text to be shown in a particular font (indicated by a string).
>
> Observe that formatted regions may be nested inside other formatted regions. For example, a bold region of text may contain one or more italic regions inside it."

The diagram below illustrates an example text document.



(a) [15 marks] In the box below, draw a *UML Class Diagram* that uses the *composite pattern* to represent text documents and their formatted regions. (Show relationships, multiplicity and class attributes in your diagram, but not methods).

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Cross out rough working that you do not want marked.
Specify the question number for work that you do want marked.

(b) [15 marks] In the box below, give Java code for the classes in your design that represent *pages*, *paragraphs* and *bold regions*. In doing this, you should follow good software engineering practice.

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Question 4. Java Fundamentals II [30 marks]

Consider the following code, **which contains a range of type errors and, hence, does not compile correctly**. Some code has been omitted and is indicated by '...'; you can assume the missing code is not responsible for any compilation problems.

```
public interface Shape { public boolean contains(int x, int y); }

public class Circle implements Shape {
  private Point midPoint; // mid point of circle
  private int radius;

  public Circle(Point mp, int r) { midPoint = mp; radius = mp; }

  public int contains(int x, int y) { ... }
  public int midPoint() { return midPoint; }
  public int radius() { return radius; }
}

public class Square implements Shape {
  private Point[] points = new int[4]; // four corners of square

  public Square(Point p1, Point p2, Point p3, Point p4) { ... }

  public Point[] getPoints() { return points; }
}

public class Main {
  public String check(double x, double y, List<Square> shapes) {
    for(Shape s : shapes) {
      if(!s.contains(x,y)) { return false; }
    }
    return true;
  }

  public static void main(String[] args) {
    List<Circle> circles = new ArrayList<Circle>();
    circles.add(new Circle(new Point(10,10),0));
    circles.add(new Square(new Point(20,20), new Point(30,"20"),
                           new Point(30,30), new Point(20,30)));
    double x1 = 1.0, y1 = 2.0;
    check(x1, y1, circles);

    int x2 = 1, y2 = 2;
    check(x2, y2, new ArrayList<Square>());
} }
```

Student ID: .....

(a) [12 marks] Circle and number six separate problems with the code on the previous page that prevent it from compiling. For each problem, write a brief (i.e. one or two line) description of the problem in the corresponding box below.

1)

2)

3)

4)

5)

6)

(b) [5 marks] Suppose there are two classes, `X` and `Y`, where `Y` is known to be a *subtype* of `X` (i.e. `X` $\geq$ `Y`). What can you tell about the relationship between `X` and `Y`?

(c) [3 marks] Consider the last line on the previous page, which reads "`check(x2,y2,new ArrayList<Shape>())`". **This line contains no errors**. Therefore, what can you tell about the relationship between types `double` and `int`?

(d) [10 marks] The following `NonNullList` class implements a list which cannot hold `null`. Carefully and neatly make this class into a generic `NonNullList`, so that it can store any kind of object.

```
public class NonNullList implements Iterable {

  private List list;

  public NonNullList(List list) { this.list = list; }

  public NonNullList() { list = new ArrayList(); }

  public boolean add(Object x) {

    if(x == null) {

     return false;

    } else {

      return list.add(x);

    }

  }

  public boolean remove(Object x) {

    if(x == null) {

     return false;

    } else {

      return list.remove(x);
    }

  }

  public Object get(int index) { return list.get(index); }

  public int size() { return list.size(); }

  public Iterator iterator() { return list.iterator(); }
}
```

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Cross out rough working that you do not want marked.
Specify the question number for work that you do want marked.

Question 5. Practices of Software Engineering II [30 marks]

Consider the following Java classes which compile correctly, and the outline of a JUnit class for testing them given below:

```
public class Competitor {
  final String name;
  final int time;
  Competitor(String n, int t) {name = n; time = t; }
}

public class TopThree {
  private Competitor gold, silver, bronze;
  public Competitor getGold() { return gold;}
  public Competitor getSilver() { return silver;}
  public Competitor getBronze() { return bronze;}

  public void time(Competitor comp) {
    Competitor c = comp;
    // if no gold competitor, then add one
    if (gold == null) {gold = comp; return;}
    // if time is better (i.e.  faster), then replace gold competitor
    if (c.time < gold.time) { comp = gold; gold = c; c = comp;}
    // if no silver competitor, then add one
    if (silver == null) {silver = comp; return;}
    // if time is better (i.e.  faster), then replace silver competitor
    if (comp.time < silver.time) { comp = silver; silver = c; }
    // if no bronze competitor, then add one
    if (bronze == null) { bronze = comp; return; }
    // if time is better (i.e.  faster), then replace bronze competitor
    if (comp.time > bronze.time) { bronze = comp; }
} }

public class TopThreeTest {
  private Competitor sam, joe, bill, derek;
  private TopThree topThree = new TopThree();

  @Before public void setUp() {
    sam = new Competitor("Speedy Sam",100);
    joe = new Competitor("Jumping Joe", 120);
    bill = new Competitor("Bouncing Bill", 150);
    derek = new Competitor("Daring Derek", 140);

    topThree.time(sam);
    topThree.time(joe);
    topThree.time(bill);
    topThree.time(derek);
  }
  ... // test cases go here
}
```

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(a) [10 marks] Each of the following JUnit test methods are part of the `TopThreeTest` class. For each, state whether it passes or fails — if it fails, explain why.

1)

```
@Test public void testGold() {
    assertSame(topThree.getGold(),sam);
}
```

2)

```
@Test public void testSilver() {
  assertEquals(topThree.getSilver(),joe);
}
```

3)

```
 @Test public void testBronze() {
    assertSame(topThree.getBronze(),derek);
 }
```

4)

```
@Test public void testGoldReversed() {
    TopThree tt = new TopThree();
    tt.time(derek);
    tt.time(joe);
    tt.time(bill);
    tt.time(sam);
    assertSame(tt.getGold(),sam);
}
```

5)

```
@Test(expected= NullPointerException.class)
public void testError() {
    TopThree tt = new TopThree();
    assertNull(tt.getGold());
}
```

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(b) Consider the following Java class which compiles and runs correctly, and the outline of a JUnit class for testing it given below:

```
public class SimpleStack<E> {
  private List<E> rep = new ArrayList<E>();

  public void push(E e) {rep.add(0, e); }
  public E pop() {return rep.remove(0); }
  public boolean isEmpty() {return rep.isEmpty(); }
}

public class SimpleStackTest {
  private SimpleStack<String> sss;

  @Before public void setUp() { sss = new SimpleStack<String>(); }

  ... // tests cases go here
}
```

(i) [15 marks] Write JUnit test methods that could be added into this class to test the following:

1. That a new stack is empty.
2. That a stack with something pushed onto it is not empty.
3. That if you push something onto a new stack, then pop it off again, the stack is still empty.
4. That you can push "null" onto a stack of Strings.
5. That you can push three integers onto a stack of integers, and they are popped off in reverse order.

1)

2)

3)

4)

5)

(ii) [5 marks] Explain why you should write tests **BEFORE** you write method code.

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Question 6. Principles of Software Design II [30 marks]

This question is about the DataVault interface listed below:

```
/** A DataVault stores data safely.  The data can be any kind of Object
 * and is associated with a String via store/get (like a Hashtable). Data
 * in the Vault is stored in a series of snapshots (copies of the
 * DataVault).  snapshot() makes a new snapshot, while revertToSnapshot()
 * takes the DataVault back to an earlier snapshot.  Finally, dump()
 * saves memory by deleting old snapshots that are still stored, and can
 * be used to get a copy of all data in the vault.  The DataVault can
 * backup data to disk.
 */
public interface DataVault {
  /** Stores new (name,value) pair in the vault for current snapshot.
   * @param propertyName - name where the value is to be stored
   * @param value - what is stored at that name */
  void storeProperty(String propertyName, Object value);

  /** Return the current value of a property from the current snapshot
   * @param name - name that will be looked up in the vault
   * @return value stored with that name, or "MISSING" if not there. */
  Object getProp(String name);

  /** Make a new snapshot and return the id number of that snapshot.
   * (Calling snapshot twice writes contents of the vault to disk)
   * @return the number of the new snapshot */
  int snapshot();

  /** Make the contents of the Vault go back to an earlier snapshot.
   * @param snapshot - the number of the snapshot to go back to
   * @return true if the snapshot exists, false if it doesnt */
  boolean revertToSnapshot(int snapshot);

  /** This method deletes old snapshots.
   * @param i - delete all snapshots before i
   * @return true if it worked */
  boolean dump(int i);

  /** This dumps all information out of the vault.
   * @return Object array containing all the information. Even numbered
   * entries in this array (0,2,4) have an Integer which is a snapshot
   * number. Odd numbered entries are: "DELETED" if that snapshot number
   * is missing (i.e. has been deleted); "DISK" if that snapshot is only
   * on disk; or a Hashtable of (name,value) pairs for a valid snapshot.
   * Warning: be very very careful if you update this array / Hashtable.
   * You might break the whole Vault */
   Object[]  dump(); /* return all information in vault. May be slow */
}
```

Student ID: . . . . . .

(a) [12 marks] Circle and number six separate problems with the design of the DataVault interface on the previous page. For each problem, write a brief (i.e. one or two line) description of the problem in the corresponding box below.

1)

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5)

6)

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Cross out rough working that you do not want marked.
Specify the question number for work that you do want marked.

(b) [18 marks] In the box below, write a Java interface and JavaDoc comments for your own replacement DataVault specification.

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Specify the question number for work that you do want marked.

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